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CEPT **ECC**  
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## CEPT Report

Report from CEPT to the European Commission in  
response to the Second Mandate to CEPT on mobile  
communication services on board aircraft (MCA)

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## 0 EXECUTIVE SUMMARY

This CEPT Report considers the technical impact on ground-based public network of introducing a new Mobile Communication service on board aircraft based on UMTS or LTE technologies operating at height of at least 3000 meter above ground in the 1800 MHz (1710-1785 MHz for the uplink and 1805-1880 MHz for the downlink), in the 2600 MHz (2500 -2570 MHz for uplink and 2620-2690 MHz for downlink) as of LTE and in the 2100 MHz (1920-1980 MHz for uplink and 2110-2170 MHz for downlink) as of UMTS. This report is based on the ECC Report 187 [1].

Emission from mobile terminals on board aircrafts as well as from on board picocells was considered for the following bands (connectivity bands):

- 1920-1980 MHz (uplink) / 2110-2170MHz (downlink)
- 1710-1785 MHz (uplink) / 1805-1880 MHz (downlink)
- 2500-2570 MHz (uplink) / 2620-2690 MHz (downlink).

It is highlighted that, in line with the basic analysis carried out in the ECC Report 187, connectivity in the 2500-2570 / 2620-2690 MHz was found to be incompatible with radar systems in the adjacent band and hence without further analysis it is concluded that this band cannot be made available for connectivity at the present time. Connectivity in the bands 1710-1785 / 1805-1880 MHz for LTE and 1920-1980 / 2110-2170 MHz for UMTS on board aircraft was found to be compatible with ground-based systems.

This CEPT Report concludes on the following additional connectivity bands and associated technical conditions:

### In the 2100 MHz connectivity band (UMTS technology, FDD):

- the transmit power of the UMTS terminal must not exceed -6 dBm/3.84MHz and the maximum number of users should not exceed 20;
- the e.i.r.p. of the ac-UE defined outside the aircraft must not exceed the following values as shown in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-UE in (dBm/3.84 MHz)
3000	3.1
4000	5.6
5000	7
6000	7
7000	7
8000	7

- the transmit power of ac-NodeB must not exceed the maximum e.i.r.p. defined outside the aircraft as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-NodeB (dBm/3.84 MHz)
3000	1.0
4000	3.5
5000	5.4
6000	7.0
7000	8.3
8000	9.5

**In the 1800 MHz connectivity band (LTE technology, FDD):**

- the e.i.r.p. defined outside the aircraft, resulting from the LTE terminal transmitting at 5 dBm/5 MHz inside the aircraft must not exceed the values as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-UE in (dBm/5 MHz)
3000	1.7
4000	3.9
5000	5
6000	5
7000	5
8000	5

- the transmit power of ac-NodeB must not exceed the maximum e.i.r.p. defined outside the aircraft as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-NodeB (dBm/5 MHz)
3000	1.0
4000	3.5
5000	5.5
6000	7.1
7000	8.4
8000	9.6

**Frequency bands controlled by NCU**

With respect to the controlled NCU bands, the studies have shown that there is no change in the power levels defined outside the aircraft for frequency bands at 460 MHz, 900 MHz, 1800 MHz and 2100 MHz as provided in the Commission Decision 2008/294/EC [7].

The e.i.r.p. of the NCU at 2600 MHz must not exceed the maximum e.i.r.p. defined outside the aircraft as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the NCU (dBm/4.75 MHz)
3000	1.9
4000	4.4
5000	6.3
6000	7.9
7000	9.3
8000	10.4

The e.i.r.p. of the NCU at 800 MHz band must not exceed the values as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the NCU (dBm/10 MHz)
3000	-0.87
4000	1.63
5000	3.57
6000	5.15
7000	6.49
8000	7.65



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## LIST OF ABBREVIATIONS

Abbreviation	Explanation
<b>ACLR</b>	Adjacent Channel leakage ratio
<b>ac-Node B/BTS</b>	Aircraft base station
<b>ac-UE/MS</b>	Mobile terminal onboard an aircraft
<b>BS</b>	Base Station
<b>e.i.r.p.</b>	equivalent isotropic radiated power
<b>FDD</b>	Frequency division duplex
<b>g-Node B/BTS</b>	Ground base station
<b>g-UE/MS</b>	Ground mobile terminal
<b>GSM</b>	Global System for Mobile communication
<b>GSMOBA</b>	GSM on board aircraft
<b>LTE</b>	Long Term Evolution
<b>MCA</b>	Mobile Communication services on board Aircraft
<b>MCFN</b>	Mobile/ Fixed Communication Network
<b>MCL</b>	Minimum Coupling Loss
<b>NCU</b>	Network Control Unit
<b>PSD</b>	Power Spectral Density
<b>RAS</b>	Radio Astronomy Service
<b>RB</b>	Resource block
<b>SEAMCAT</b>	Spectrum Engineering Advanced Monte-Carlo Analysis Tool
<b>UE</b>	User Equipment
<b>UMTS</b>	Universal Mobile Telecommunications System
<b>WCDMA</b>	Wideband Code Division Multiple Access
<b>WiMAX</b>	Worldwide Interoperability for Microwave Access (IEEE 802.16)

## 1 INTRODUCTION

The European Commission has issued a second Mandate to CEPT on mobile communication services on board aircraft (MCA) to identify the most appropriate technical criteria for the inclusion of new technologies and frequencies in the EC Decision on Mobile Communication Services on Board Aircraft (MCA) (2008/294/EC [7]) to facilitate further deployment of MCA applications in the European Union.

The first Mandate given by the Commission to CEPT on 12 October 2006 on this issue led to CEPT Report 016 [9] being delivered to the Commission on 30 March 2007 (doc. RSCOM07-08) and to a subsequent Commission Decision 2008/294/EC [7] on harmonised conditions of spectrum use for the operation of mobile communication services on aircraft (MCA services) in the European Union, which was adopted by the Commission on 7 April 2008.

The objective of this second Mandate is to study the technical compatibility of airborne UMTS systems, as well as other feasible technologies like LTE or WiMAX, with potentially affected radio services. This Mandate is a follow-up to the first mandate and its purpose is to extend the scope of compatible MCA systems and services currently available.

The Second MCA Mandate comprises the following elements for study:

1. assess specific technical compatibility issues between the operation of airborne UMTS systems and other feasible airborne technologies, such as LTE or WiMAX, in relevant frequency bands, including the terrestrial 2 GHz band (1920-1980 MHz and 2110-2170 MHz), and potentially affected radio services, taking into account the technical conditions developed in CEPT Report 39 [8] for the assessment relating to the terrestrial 2 GHz band;
2. assess the technical compatibility issues between the operation of airborne UMTS systems and other feasible airborne technologies such as LTE or WiMAX in other frequency bands (e.g. the 2.6 GHz band) and identify potentially affected radio services.

In consequence, this CEPT Report is structured in two parts:

- Part 1 addresses the feasible MCA technologies and relevant frequency bands both for the connectivity and NCU parts of the MCA system. The connectivity part provides the network coverage on board, whereas the NCU (Network Control Unit) is designed to ensure that mobile terminals within the cabin cannot access ground-based networks and that they do not transmit any signal without being controlled by the MCA system by raising the noise floor inside the cabin.
- Part 2 covers the various compatibility studies (in-band and adjacent band) which were carried out resulting from the additional technologies and frequency bands for MCA considered under this mandate.



## 2 PART 1 – FEASIBLE MCA TECHNOLOGIES AND RELEVANT FREQUENCY BANDS

Commission Decision 2008/294/EC [7] specifies in Table 1 of the annex GSM in the 1800 MHz band (1710-1785 MHz and 1805-1880 MHz) as the frequency band and system allowed for MCA services (connectivity part of the MCA system). Similarly, Table 2 of the annex GSM lists those frequency bands for which it must be prevented that mobile terminals, receiving within these bands, attempt to register with mobile systems on the ground (NCU part of the MCA system) as follows:

Table 1: Frequency bands and associated technologies as identified in ECC Report 093

Frequency band	System on the ground
460-470 MHz	CDMA2000, FlashOFDM
921-960 MHz	GSM <sup>1</sup> , UMTS
1805-1880 MHz	GSM, UMTS
2110-2170 MHz	UMTS

These bands, as well as the associated technical conditions as defined in section 3 of the annex of Commission Decision 2008/294/EC [7], are based on ECC/DEC/(06)07 [2] "on the harmonised use of airborne GSM systems in the frequency bands 1710-1785 and 1805-1880 MHz" and ECC Report 093 [3] "Compatibility between GSM equipment on board aircraft and terrestrial networks" [3].

This CEPT regulatory framework for MCA was revised in 2009 to include the 2.6 GHz band for the NCU part of the MCA system. However, this addition was never transposed in the Commission Decision 2008/294/EC [7].

The first task under the second MCA mandate was therefore to study, based on the above mentioned existing list of bands and technologies, the feasible MCA technologies and frequency bands that should be considered when developing compatibility studies between MCA equipment on board aircraft and terrestrial networks.

The following bands and technologies have been identified during this process for the connectivity part of the MCA system for study:

- GSM1800 (already covered by the current Commission Decision)
- LTE1800 (FDD)
- UMTS2100 (FDD)
- LTE2600 (FDD).

A number of in-band compatibility scenarios have been identified, that need to be studied (see Part 2 of this CEPT Report).

For both the GSM1800 and the LTE1800 MCA system, compatibility with terrestrial GSM and LTE networks in this frequency bands has to be analysed (with the GSM MCA vs. GSM terrestrial case already covered in the current Commission Decision).

Additionally, with the introduction of LTE2600 as a connectivity option for the MCA system, a need was identified to also study the adjacent-band compatibility with the Radioastronomy Service (2690-2700 MHz) and Radars in the 2700-2900 MHz band as potentially affected radio services.

The following table provides a list of all bands and technologies which have been identified during this process for the NCU part of the MCA system including those already identified in the current Commission Decision 2008/294/EC [7]:

<sup>1</sup> Including GSM-R



Table 2: Updated frequency bands and associated technologies

Frequency band	System on the ground
460-470 MHz	CDMA2000, FlashOFDM
791-821 MHz	LTE
921-960 MHz	GSM, UMTS, LTE, WiMAX
1805-1880 MHz	GSM, UMTS, LTE, WiMAX
2110-2170 MHz	UMTS, LTE
2620-2690 MHz	UMTS, LTE
2570-2620 MHz	UMTS, LTE, WiMAX

Taking into account the scenarios that have already been studied in ECC Report 093 [3] the following additional scenarios have been studied:

Table 3: Compatibility scenarios to be considered

Frequency band	System on the ground
791-821 MHz	LTE
925-960 MHz	LTE, WiMAX
1805-1880 MHz	LTE, WiMAX
2110-2170 MHz	LTE
2620-2690 MHz	LTE
2570-2620 MHz	LTE

These compatibility scenarios are studied in detail within CEPT in the corresponding ECC Report 187 [1]. The scenarios and relevant results are summarised in Part 2 of this CEPT Report.

### 3 PART 2 – COMPATIBILITY STUDIES

#### 3.1 BACKGROUND TO STUDIES

Based on the frequency bands and technologies that have been identified for the connectivity part of the MCA system and systems on ground not yet covered by previous sharing studies responding to the previous mandate, the following scenarios have been identified as described in Table 4 and Table 5 hereafter.

Table 4: Identifications of sharing studies between onboard connectivity system and ground-based systems

Band	Technology on board aircraft	In-band sharing with ground-based systems	Adjacent-band sharing with ground-based systems
1800 MHz	GSM	GSM, LTE	
1800 MHz	LTE	GSM, LTE	
2100 MHz FDD	UMTS	UMTS	
2600 MHz FDD 2600 MHz TDD	LTE	LTE RAS (2655-2690 MHz)	Radioastronomy service (RAS) (2690-2700 MHz), Radars (2700-2900 MHz)

Table 5: Identification of sharing studies between ground-based network and the NCU

Band	Sharing with ground-based systems	Adjacent-band sharing with ground-based systems
450 MHz	CDMA450, FlashOFDM	
800 MHz	LTE	
900 MHz	GSM, UMTS, LTE, WiMAX	
1800 MHz	GSM, UMTS, LTE, WiMAX	
2100 MHz FDD	UMTS, LTE	
2600 MHz FDD	UMTS, LTE, RAS (2655-2690 MHz)	Radioastronomy service (RAS) (2690-2700 MHz), Radars (2700-2900 MHz)
2600 MHz TDD	UMTS, WiMAX, LTE, RAS (2655-2690 MHz)	

The NCU (Network Control Unit) is a part of the MCA system designed to ensure by raising the noise floor inside the cabin that mobile terminals within the cabin cannot access to the ground-based public networks and that those compatible with the onboard technology do not transmit any signal without being controlled by the MCA system, i.e. the onboard Node B or onboard BTS.

The considered MCA (UMTS / LTE) system is designed to ensure that a mobile terminal on board an aircraft (ac-UE) is unable to communicate with ground-based public mobile networks, whilst providing onboard connectivity to ac-UE in the LTE1800, UMTS2100 or LTE2600 frequency bands.

The new analysis in this report considers the impact of the:

- Network control unit (NCU) emissions to the ground-based downlink (base station transmit → mobile station receive link) (the new bands for control) ;
- Aircraft base station (ac-NodeB) emissions to the ground-based downlink (base station transmit → mobile station receive link), at 1800 MHz (LTE) 2100 MHz (UMTS) and 2600 MHz (LTE) only;

- Mobile terminal on aircraft (ac-UE) emissions to the ground-based uplink (mobile station transmit → base station receive link), at 1800 MHz (LTE), 2100 MHz (UMTS) and 2600 MHz (LTE).

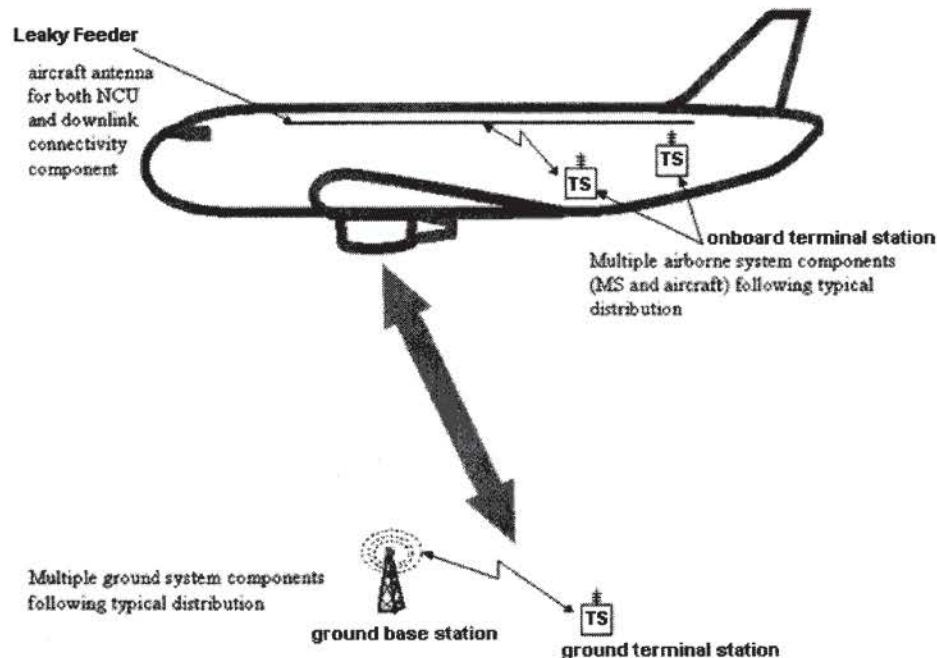


Figure 1: MCA and ground-based cellular system interference scenario

The following six scenarios have been studied when needed:

- Scenario 1: Impact of ground base station (g-NodeB) to the ac-UE. This scenario, using a minimum coupling loss (MCL) approach, identifies the conditions in which the mobile terminal on aircraft (ac-UE) will have visibility of the ground-based networks. Note that the NCU and aircraft base station (ac-NodeB) are not taken into account in this scenario.
- Scenario 2: Impact of the ac-UE to g-NodeB. This scenario, using both MCL approach and SEAMCAT analysis, assessed in which conditions the ac-UE will have the ability to connect to ground-based networks, and in that case, the impact on other ground-based links. Note that the NCU and ac-NodeB are not taken into account in this scenario.
- Scenarios 3 and 4: Impact of onboard NCU and ac-NodeB emissions to the downlink of ground-based networks, for single (Scenario 3) and multiple (Scenario 4) aircraft respectively;
- Scenarios 5 and 6: Impact of ac-UE emissions to the uplink of ground-based networks, for single (Scenario 5) and multiple (Scenario 6) aircraft respectively.

Table 6: Modelling scenarios

Scenario #	Interferers	Interfered system
1	g-NodeB	ac-UE
2	ac-UE	g-NodeB
3	NCU and ac-NodeB	Ground-based network downlink
4	Multiple aircraft NCU and ac-NodeB	Ground-based network downlink
5	ac-UE	Ground-based network uplink
6	Multiple aircraft ac-UE	Ground-based network uplink



ECC Report 093 [3] considers the technical compatibility between GSM equipment on board aircraft and ground-based public mobile networks. The additional compatibility studies performed here address the impact on ground-based public mobile networks of introducing a MCA system based on the UMTS / LTE technology operating at a height of at least 3000 metres above ground level in the following frequency bands:

- 1710-1785 MHz for uplink (terminal transmit, base station receive) / 1805-1880 MHz for downlink (base station transmit, terminal receive);
- 1920-1980 MHz for uplink (terminal transmit, base station receive) / 2110-2170 MHz for downlink (base station transmit, terminal receive);
- 2500-2570 MHz for uplink (terminal transmit, base station receive) / 2620-2690 MHz for downlink (base station transmit, terminal receive).

### 3.2 2100 MHz CONNECTIVITY ANALYSIS

#### 3.2.1 Scenario 1: Impact of g-NodeB on ac-UE

This scenario assesses in which conditions the ac-UE will have visibility of the terrestrial networks, by using MCL calculations. For the purposes of this new EC mandate, it was only necessary to repeat Scenario 1 to identify the impact of 2100 MHz LTE g-NodeB systems on ac-UE.

From the calculation for different elevation angles, the worst case elevation angle considered for the study at 2100 MHz is 48° whatever the height above ground of the aircraft. The relative antenna gain is -1.84 dBi

Table 7: Impact of g-NodeB on ac-UE at 2100 MHz

Height above ground (m)	Worst case elevation angle (deg)	Distance aircraft / base station (km)	Path loss (dB)	Antenna gain (dBi)	LTE2100		
					e.i.r.p. (dBm)	Max. received power in aircraft, $P_{\text{max rec:ac-MS}}$ (dBm/ch)	Margin(dB)
3000	48	4.04	111.2	-1.84	44.16	-72.0	-25.0
4000	48	5.38	113.7	-1.84	44.16	-74.5	-22.5
5000	48	6.73	115.6	-1.84	44.16	-76.4	-20.6
6000	48	8.07	117.2	-1.84	44.16	-78.0	-19.0
7000	48	9.42	118.5	-1.84	44.16	-79.4	-17.6
8000	48	10.76	119.7	-1.84	44.16	-80.5	-16.5
9000	48	12.1	120.7	-1.84	44.16	-81.5	-15.5
10000	48	13.45	121.6	-1.84	44.16	-82.5	-14.5

A negative margin means that an extra isolation is necessary to remove the visibility of the ground networks.

### 3.2.2 Scenario 2: Impact of ac-UE on g-NodeB

This scenario assesses in which conditions the onboard ac-UE will have the ability to connect to terrestrial networks.

Table 8: impact of ac-UE on g-NodeB at 2100 MHz

Aircraft height above ground (m)	Worst case elevation angle (deg)	Distance aircraft / g-UE (km)	Path loss (dB)	Rx Ant. Gain (dBi) at given angle	LTE2100		
					e.i.r.p. (dBm)	Max. received power on ground, $P_{\text{max rec: g node B}}$ (dBm/ch)	Margin(dB)
3000	48	4.04	111.2	-1.84	23	-95.0	-6.5
4000	48	5.38	113.7	-1.84	23	-97.5	-4.0
5000	48	6.73	115.6	-1.84	23	-99.4	-2.1
6000	48	8.07	117.2	-1.84	23	-101.0	-0.5
7000	48	9.42	118.5	-1.84	23	-102.4	0.9
8000	48	10.76	119.7	-1.84	23	-103.5	2.0
9000	48	12.10	120.7	-1.84	23	-104.5	3.0
10000	48	13.45	121.6	-1.84	23	-105.5	4.0

A negative margin shows that it is possible that an UE could connect to a ground-based mobile network

### 3.2.3 Scenario 3: Impact of the NCU on g-UE

In this frequency band, the ECC/DEC/(06)07 [2] provides the maximum e.i.r.p. defined outside the aircraft. At the first stage, the minimum value needed to screen the LTE ground network should be defined and calculate what the increase of noise floor will be.

Table 9: MCL result of impact of the NCU on g-UE

Height above ground (km) $\Rightarrow$	3	4	5	6	7	8	9	10
Max received Signal Level (dBm/channel) inside aircraft	-72.0	-74.5	-76.4	-78.0	-79.4	-80.5	-81.5	-82.5
Radiation Factor (Large Aircraft) (dB)	71	71	71	71	71	71	71	71
Aircraft Attenuation for leaky feeder transmission (dB)	10	10	10	10	10	10	10	10
Equivalent e.i.r.p. (as point of source) (dBm/channel)	-11.0	-13.5	-15.4	-17.0	-18.4	-19.5	-20.5	-21.5
Free Space Propagation Losses (dB)	108.6	111.1	113.0	114.6	116.0	117.1	118.1	119.0
Maximum Received Noise by g-UE (dBm)	-119.6	-124.6	-128.5	-131.6	-134.3	-136.6	-138.7	-140.5
System Noise Level, reference values (dB/channel)	-95	-95	-95	-95	-95	-95	-95	-95
Increase of the noise floor at g-UE with respect to reference values (dB)	0.015	0.005	0.002	0.001	0.001	0.000	0.000	0.000
Equivalent e.i.r.p. (as point of source) (dBm/ 200 kHz)	-28.01	-30.49	-32.44	-34.02	-35.36	-36.51	-37.53	-38.45



The above table shows that the increase of noise floor at ground UE remains below 1 dB. It also shows that the value needed to screen the ground LTE2100 cellular network is below the e.i.r.p. limit defined in the ECC/DEC/(06)07 [2].

Instead of performing all the SEAMCAT simulations starting from the result contained in Table 9 above, it was proposed to use the e.i.r.p. limit as contained in the ECC/DEC/(06)07 [2] and to perform only the scenario 4 in which several interferers will be taken into account.

### 3.2.4 Scenario 4: Impact of the NCU and UMTS connectivity on ground network

The e.i.r.p. used is the one as defined in the ECC/DEC/(06)07 [2] at 3000 m.

#### 3.2.4.1 Impact of the UMTS connectivity to the ground network

Table 10 below provides the impact of UMTS connectivity system onboard aircraft to the ground network.

Table 10: Simulation result for scenario 4

Description of the case		Reference cell	CDMA system
		Average capacity loss	Average capacity loss
Multiple ac-BTS to terrestrial UMTS network	Normal day (4 interferers)	0%	3.72%
Multiple ac-BTS to terrestrial UMTS network	Busy day (8 interferers)	0 %	2.35%

#### 3.2.4.2 Impact of the NCU on the ground network

Table 11 below provides the impact of the NCU to the ground LTE network.

Table 11: Simulation result for scenario 4

Description of the case		Reference cell		OFDMA system	
		Average capacity loss	Average bitrate loss	Average capacity loss	Average bitrate loss
Multiple NCU to terrestrial LTE network	Normal day (18 interferers)	0%	0.005%	0 %	0.003 %
Multiple NCU to terrestrial LTE network	Extreme busy day (33 interferers)	0 %	0.009%	0%	0.005%

### 3.2.5 Scenario 5: Impact of the ac\_UE on ground based communications (g-UE to g-NodeB) from a single aircraft

In this scenario the impact of the ac-UE (single aircraft) on the terrestrial UMTS networks on the uplink communications link between the g-UE to the g-BTS was studied.

The results in Table 12 below identify that the protection threshold for ground based systems (single aircraft) is met assuming a maximum number of simultaneous users of 20 transmitting at -6 dBm.



Table 12: Simulation results with number of simultaneous ac\_UE=20

Height above ground (m)	Average Capacity Loss	
	e.i.r.p. ac-UE= -6dBm	
	Reference cell	CDMA system
3000	3.74%	0.00%
5000	0.03%	0.00%
8000	0.03%	0.00%

### 3.2.6 Scenario 6: Impact of the ac\_UE on ground based communications (g-UE to g-NodeB) from multiple aircraft

In this scenario the impact of the ac-UE (multiple aircrafts) on the terrestrial UMTS networks on the uplink communications link between the g-UE to the g-BTS was studied.

The results in the table below identify that the protection threshold for ground based systems (multiple aircrafts) is met assuming a maximum number of simultaneous users of 20 transmitting at -6 dBm.

Table 13: Simulation results with number of simultaneous ac\_UE=20

Description of the case		Average Capacity Loss	
		e.i.r.p. ac-UE= -6dBm	
		Reference cell	CDMA system
Multiple ac_UE to terrestrial UMTS network	Normal day	0.22%	0 %
Multiple ac_UE to terrestrial UMTS network	Busy day	0.38%	0%

The results in the above table identify that the protection threshold for ground based systems (multiple aircraft) is met assuming a maximum number of simultaneous users of 20 transmitting at -6dBm.

The following results in the table below show that the average capacity loss remains below 5%.

Table 14: MCL simulation results

Height above ground (m)	MCL, 1 dB increased noise floor				Effective attenuation (dB)	Max permitted e.i.r.p. (dBm/channel)
	Aircraft attenuation (dB)	Ac-UE power (dBm)	Multiple user factor (dB)	Required attenuation (dB)		
3000	5	-6	13	-1.1	3.9	3.1
4000	5	-6	13	-3.6	1.4	5.6
5000	5	-6	13	-5.5	0	7
6000	5	-6	13	-7.1	0	7
7000	5	-6	13	-8.5	0	7
8000	5	-6	13	-9.6	0	7

### 3.3 1800 MHz CONNECTIVITY ANALYSIS

#### 3.3.1 Scenario 1: Impact of g-base station on ac-UE

This scenario assesses in which conditions the ac-UE will have visibility of the terrestrial LTE1800 networks, by using MCL calculations because ECC Report 093 [3] -in all cases - shows MCL calculations to represent the worst case scenario. Therefore, there was no requirement for further statistical analysis.

The worst case elevation angle is 48 °, corresponding to an antenna gain of -1.84 dBi.

Table 15: Impact of g-LTE base station on ac-UE at 1800 MHz

Aircraft height above ground (m)	Worst case elevation angle (deg)	Distance aircraft / base station (km)	Path loss (dB)	Ant. Gain (dBi) at given angle	LTE1800		
					e.i.r.p. (dBm)	Max. received power in aircraft, $P_{\max \text{ rec:ac-MS}}$ (dBm/ch)	Margin (dB)
3000	48	4.04	109.9	-1.84	41.16	-73.7	-26.3
4000	48	5.38	112.4	-1.84	41.16	-76.2	-23.8
5000	48	6.73	114.3	-1.84	41.16	-78.1	-21.9
6000	48	8.07	115.9	-1.84	41.16	-79.7	-20.3
7000	48	9.42	117.2	-1.84	41.16	-81.1	-18.9
8000	48	10.76	118.4	-1.84	41.16	-82.2	-17.8
9000	48	12.1	119.4	-1.84	41.16	-83.2	-16.8
10000	48	13.45	120.3	-1.84	41.16	-84.2	-15.8

A negative margin means that an extra isolation is necessary to remove the visibility of the ground networks.

#### 3.3.2 Scenario 2: Impact of ac-UE on g-base station

This scenario assesses in which conditions the onboard ac-UE will have the ability to connect to terrestrial networks.

Table 16: impact of ac-UE on g-base station at 1800 MHz

Aircraft height above ground (m)	Worst case elevation angle (deg)	Distance aircraft / g_UE (km)	Path loss (dB)	Rx Ant. Gain (dBi) at given angle	LTE1800		
					UE e.i.r.p. (dBm)	Max. received power on ground, $P_{\max \text{ rec: g node B}}$ (dBm/ch)	Margin (dB)
3000	48	4.04	109.9	-1.84	23	-93.7	-7.8
4000	48	5.38	112.4	-1.84	23	-96.2	-5.3
5000	48	6.73	114.3	-1.84	23	-98.1	-3.4
6000	48	8.07	115.9	-1.84	23	-99.7	-1.8
7000	48	9.42	117.2	-1.84	23	-101.1	-0.4
8000	48	10.76	118.4	-1.84	23	-102.2	0.7
9000	48	12.1	119.4	-1.84	23	-103.2	1.7
10000	48	13.45	120.3	-1.84	23	-104.2	2.7

A negative margin shows that it is possible that an UE could connect to a ground-based mobile network.



### 3.3.3 Estimation of the maximum power level emitted by the onboard node B

Based on the ECC/DEC/(06)07 [2] and taken into account the fact that the GSM mobile terminal will transmit 0 dBm, then it is possible to determine the minimum aircraft attenuation as shown in Table 17.

Table 17: Aircraft attenuation

Height above ground (m)	Aircraft attenuation (dB)
3000	3.3
4000	1.1
5000	-0.5
6000	-1.8
7000	-2.9
8000	-3.8

From Table 17, it is possible to estimate the e.i.r.p. outside the aircraft with the following formula:

e.i.r.p. (dBm/Channel)= Max received signal + Radiation factor – aircraft attenuation + 5 dB (this value was used as initial assumption in the ECC Report 093 [3]).

Then, from the calculated e.i.r.p., the increase of noise level will be estimated.

Table 18: MCL calculation

Height above ground (m) ⇒	3000	4000	5000	6000	7000	8000
Max received signal level (dBm/5MHz)	-73.7	-76.2	-78.1	-79.7	-81.1	-82.2
Radiation Factor (Large Aircraft) (dB)	70	70	70	70	70	70
Aircraft Attenuation (dB)	3.3	1.1	-0.5	-1.8	-2.9	-3.8
Equivalent e.i.r.p. (as point of source) (dBm/5MHz)	-1.0	-1.3	-1.6	-1.9	-2.2	-2.4
Free Space Propagation Losses (dB)	107.3	109.8	111.7	113.3	114.6	115.8
Maximum Received Noise by g-MS (dBm)	-108.3	-111.1	-113.4	-115.2	-116.8	-118.2
System Noise Level, reference values (dB/bw)	-100	-100	-100	-100	-100	-100
Increase of the noise floor at g-MS with respect to reference values (dB)	0.60	0.33	0.20	0.13	0.09	0.06

From Table 18, it is then possible to calculate the required attenuation in order to get the 1 dB increase noise floor at the ground UE:

Table 19: Calculation of maximum e.i.r.p.

Height above ground (km)	MCL, 1 dB increased noise floor			Maximum e.i.r.p. produced by the ac-nodeB (dBm/5 MHz)	Maximum e.i.r.p. produced by the ac-nodeB (dBm/200 kHz)
	MS attenuation (dB)	Ac-nodeB power (dBm)	Required attenuation (dB)		
3	3.3	-1	-2.43	1.43	-12.55
4	1.1	-1.3	-5.22	3.92	-10.06
5	-0.5	-1.6	-7.50	5.9	-8.08
6	-1.8	-1.9	-9.36	7.46	-6.52
7	-2.9	-2.2	-10.94	8.74	-5.24
8	-3.8	-2.4	-12.36	9.96	-4.02



Based on the result of the maximum e.i.r.p., defined outside the aircraft and produced by the ac-NodeB in 1800 MHz, it can be seen that the limit contained in the ECC/DEC/(06)07 [2] in the band 1800 MHz remains.

### 3.3.4 Scenario 5: Impact of ac-UE to ground-based network uplink

Table 20: MCL calculation for ac-UE1800 MHz to terrestrial LTE networks

Height above ground (km) ⇒	3	4	5	6	7	8	9	10
Distance g-nodeB/ ac-UE (km)	4.04	5.38	6.73	8.07	9.42	10.76	12.1	13.45
UE power level (dBm/5 MHz)	5	5	5	5	5	5	5	5
Aircraft Attenuation (dB)	3.3	1.1	0	0	0	0	0	0
e.i.r.p. outside the aircraft (dBm/5 MHz)	1.7	3.9	5	5	5	5	5	5
Free Space Propagation Losses (dB)	109.4	111.9	113.8	115.4	116.7	117.9	118.9	119.8
Terrestrial LTE antenna Gain (dBi)	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8	-1.8
Maximum Received Noise by g-MS (dBm/5 MHz)	-109.5	-109.8	-110.6	-112.2	-113.5	-114.7	-115.7	-116.6
System Noise Level, reference values (dBm/5 MHz)	-102	-102	-102	-102	-102	-102	-102	-102
Increase of the noise floor at g-MS with respect to reference values (dB)	0.71	0.67	0.56	0.40	0.30	0.23	0.18	0.15

The table above shows that the increase of noise remains below 1 dB.

## 3.4 800 MHz NCU ANALYSIS

### 3.4.1 Scenario 3: Impact of the NCU on g-UE at 800 MHz

This scenario assesses the impact of onboard NCU emissions on the ground-based UE receivers, by using MCL calculations.

Table 21: Impact of a signal NCU to terrestrial LTE network

Height above ground (km)	3	4	5	6	7	8	9	10
Max received Signal Level (dBm/channel) inside aircraft	-58.92	-61.44	-63.34	-64.94	-66.24	-67.44	-68.44	-69.34
Radiation Factor (Large Aircraft) (dB)	64	64	64	64	64	64	64	64
Aircraft Attenuation for leaky feeder transmission (dB)	10	10	10	10	10	10	10	10
Equivalent e.i.r.p. (as point of source) (dBm/10 MHz)	-4.92	-7.44	-9.34	-10.94	-12.24	-13.44	-14.44	-15.34
Free Space Propagation Losses (dB)	100.00	102.50	104.44	106.02	107.36	108.52	109.55	110.46
Maximum Received Noise by g-UE (dBm/channel)	-104.92	-109.94	-113.78	-116.96	-119.60	-121.96	-123.99	-125.80
System Noise Level, reference values (dBm/channel)	-95	-95	-95	-95	-95	-95	-95	-95
Increase of the noise floor at g-UE with respect to reference values (dB)	0.42	0.14	0.06	0.03	0.02	0.01	0.01	0.00

From the results of Table 21, it is then possible to calculate, for different height above ground of the aircraft what the equivalent e.i.r.p. of the NCU should be to get 1 dB increase of noise floor at ground UE. These values are contained in Table 22.

Table 22: Maximum e.i.r.p. of the NCU

Height above ground (km)	3	4	5	6	7	8	9	10
Equivalent e.i.r.p. (dBm/10 MHz)	-0.87	1.63	3.57	5.15	6.49	7.65	8.68	9.59

The Table 23 below provides the results of SEAMCAT simulations for average capacity loss

Table 23: Average capacity loss

Situation		Reference Cell		OFDMA System	
Description of the case		Average capacity loss	Average bitrate loss	Average capacity loss	Average bitrate loss
NCU transmitting in the 800 MHz band over terrestrial LTE networks	Transmitter placed randomly within a radius of 17 km at 3 km above ground	0 %	0.001 %	0 %	0 %
	Transmitter placed randomly within a radius of 28 km at 5 km above ground	0 %	0.02 %	0 %	0.001 %
	Transmitter placed randomly within a radius of 45 km at 8 km above ground	0 %	0.002 %	0 %	0.001 %
	Transmitter placed randomly within a radius of 56 km at 10 km above ground	0 %	0.002 %	0 %	0.001 %

### 3.4.2 Scenario 4: impact of multiple NCU on g-UE at 800 MHz

Table 24 provides the result for the scenario 4.

Table 24: Simulation result for scenario 4

Description of the case		Reference cell		OFDMA system	
		Average capacity loss	Average bitrate loss	Average capacity loss	Average bitrate loss
Multiple NCU to terrestrial LTE network	Normal day (18 interferers)	0%	0.006%	0 %	0.003 %
Multiple NCU to terrestrial LTE network	Extreme busy day (33 interferers)	0%	0.01%	0 %	0.004 %

The result shows that the average capacity loss remains below 1%.

## 3.5 PROTECTION OF ADJACENT SERVICES

### 3.5.1 Radio astronomy services in the 2690-2700 MHz

For the bands in question, the appropriate threshold of interference level of spectral power flux density taken from Table 1 of Recommendation ITU-R RA.769-2 [5] (continuum observations) is -247 dB(W/m<sup>2</sup>.Hz), which equates to a maximum interference power level in a notional 10 MHz bandwidth of -177 dBm. This threshold of interference level is also based on an assumed observational integration time of 2000 s. Continuum observations made with single-dish telescopes commonly undertaken in European observatories are well characterised by these parameters.

Assuming the aircraft is in line of sight of an observatory, at these frequencies the path loss 'L' may be calculated to a reasonable approximation based on the free space path loss equation (i.e. For 3000 m Height above ground at 2695 MHz, L = 110.6 dB). For the scenario stated, the power 'P<sub>ext</sub>' outside the aircraft at 3000 m falling into the band must therefore be less than:

$$P_{\text{ext}} = -177 + 110.6 = -66.4 \text{ dBm/10 MHz}$$



### 3.5.2 Radar services operating above 2700 MHz

The impact of MCA system operating in 2500-2690 MHz band on radar system above 2700 MHz band was assessed. This analysis assumes radar performance parameters identical to ECC Report 174 [4]. Table 25 and Table 26 present the results of the compatibility studies with adjacent band radar services.

Table 25: Power Spectral Density at victim receiver (radar) from 3000 m to 10000 m and  $(I+N)/N$

Aircraft height (m)	Free Space Path Loss (from onboard equipment to victim receiver) (dB)	Power received by the radar $P_{v-Rx}$ (dBm/MHz)	Increase in noise level $(I+N)/N$ (dB)	Power received by the radar $P_{v-Rx}$ (dBm/MHz)	Increase in noise level $(I+N)/N$ (dB)
		Type 1		Type 2 and 3	
3000	110.36	-141.3	0.051	-147.3	0.013
4000	112.86	-143.8	0.029	-149.8	0.007
5000	114.80	-145.7	0.018	-151.7	0.005
6000	116.38	-147.3	0.013	-153.3	0.003
7000	117.72	-148.6	0.009	-154.6	0.002
8000	118.88	-149.8	0.007	-155.8	0.002
9000	119.90	-150.8	0.006	-156.8	0.001
10000	120.82	-151.7	0.004	-157.7	0.001

With respect to the radar type 4, the worst case is when the aircraft is at 37° elevation angle from the radar, and the elevation angle of the radar antenna is at 37°.

Table 26: Power Spectral Density at victim receiver (radar) from 3000 m to 10000 m and  $(I+N)/N$  for radar type 4

Aircraft height (m)	Free Space Path Loss (from onboard equipment to radar) (dB)	Power received by the radar $P_{v-Rx}$ (dBm/MHz)	Increase in noise level $(I+N)/N$ (dB)
3000	114.81	-128.68	0.84
4000	117.31	-131.18	0.50
5000	119.25	-133.12	0.32
6000	120.83	-134.70	0.23
7000	122.17	-136.04	0.17
8000	123.33	-182.19	0.00
9000	124.35	-138.22	0.10
10000	125.26	-139.13	0.08

From the protection criteria for Radar  $I/N = -10\text{dB}$  (Recommendation ITU-R M.1464-1) [6] it is derived the criterion  $(I+N)/N = 0.41\text{dB}$ . The results in Table 26 indicate that the increase in noise floor at the victim receiver is exceeding the protection level for Radar type 4, i.e.  $> 0.41\text{dB}$ , whereas the other type of radars are compliant with the protection level.

Based on the basic analysis carried out, compatibility with adjacent band radar services could not be ensured, therefore without further analysis at this present time it is concluded that this band could not be made available for connectivity.



#### 4 CONCLUSIONS

This CEPT Report based on the ECC Report 187 [1], described additional studies on the compatibility of a MCA system with terrestrial networks, when the aircraft is at least 3000 m above ground. The studies demonstrated that harmful interference to terrestrial networks will not occur provided that the following technical conditions are met:

##### In the 2100 MHz connectivity band (UMTS technology, FDD):

- the transmit power of the UMTS terminal must not exceed -6 dBm/3.84MHz and the maximum number of users should not exceed 20;
- the e.i.r.p. of the ac-UE defined outside the aircraft must not exceed the following values as shown in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-UE in (dBm/3.84 MHz)
3000	3.1
4000	5.6
5000	7
6000	7
7000	7
8000	7

- the transmit power of ac-NodeB must not exceed the maximum e.i.r.p. defined outside the aircraft as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-NodeB (dBm/3.84 MHz)
3000	1.0
4000	3.5
5000	5.4
6000	7.0
7000	8.3
8000	9.5

##### In the 1800 MHz connectivity band (LTE technology, FDD):

- the e.i.r.p. defined outside the aircraft, resulting from the LTE terminal transmitting at 5 dBm/5 MHz inside the aircraft must not exceed the values as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-UE in (dBm/5 MHz)
3000	1.7
4000	3.9
5000	5
6000	5
7000	5
8000	5

- the transmit power of ac-NodeB must not exceed the maximum e.i.r.p. defined outside the aircraft as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the ac-NodeB (dBm/5 MHz)
3000	1.0
4000	3.5
5000	5.5
6000	7.1
7000	8.4
8000	9.6

#### In the 2600 MHz connectivity band (LTE technology, FDD)

Compatibility with the adjacent band Radio astronomy service primary allocation at 2690-2700 MHz can be achieved assuming that the out-of-band emission outside the aircraft is lower than – 66.4 dBm/10 MHz at 3000 metres. To achieve compatibility with the RAS secondary allocation in the shared band at 2655-2690 MHz would require the same limit on emissions.

It was found that in the 2600 MHz connectivity band, based on the basic analysis carried out in this report that compatibility with adjacent band radar services could not be ensured. Therefore without further analysis it is concluded that this band cannot be made available for connectivity.

#### Frequency bands controlled by NCU

With respect to the controlled NCU bands, the studies have shown that there is no change in the power levels defined outside the aircraft for the frequency bands at 460 MHz, 900 MHz, 1800 MHz and 2100 MHz as provided in the Commission Decision 2008/294/EC [7].

The e.i.r.p. of the NCU at 2600 MHz must not exceed the maximum e.i.r.p. defined outside the aircraft as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the NCU (dBm/4.75 MHz)
3000	1.9
4000	4.4
5000	6.3
6000	7.9
7000	9.3
8000	10.4

The e.i.r.p. of the NCU at 800 MHz band must not exceed the values as provided in the table below:

Height above ground (m)	Maximum e.i.r.p. defined outside the aircraft, resulting from the NCU (dBm/10 MHz)
3000	-0.87
4000	1.63
5000	3.57
6000	5.15
7000	6.49
8000	7.65

## ANNEX 1: CEPT MANDATE



**EUROPEAN COMMISSION**  
 Information Society and Media Directorate-General  
 Electronic Communications Policy  
 Radio Spectrum Policy

Brussels, 05 October 2011  
 DG INFSO/B4

**ADOPTED**

**SECOND MANDATE TO CEPT**  
**TO UNDERTAKE TECHNICAL STUDIES ON MOBILE COMMUNICATION SERVICES ON BOARD**  
**AIRCRAFT (MCA)**

**PURPOSE**

Pursuant to Art. 4 of the Radio Spectrum Decision 676/2002/EC<sup>2</sup>, CEPT is mandated to undertake the work required to identify the most appropriate technical criteria for the inclusion of new technologies and frequencies in the EC Decision on Mobile Communication Services on Board Aircraft (MCA) (2008/294/EC) to facilitate further deployment of MCA applications in the European Union.

The objective of this Mandate is to study the technical compatibility of airborne UMTS systems, as well as other feasible technologies like LTE or WiMax, with potentially affected radio services. This Mandate is a follow-up to the first EC Mandate on MCA of 12 October 2006, and its purpose is to extend the scope of compatible MCA systems and services currently available.

In the European Union, the airworthiness of airborne mobile communication systems in terms of avoiding the creation of harmful interference to aviation systems is the competence of the European Aviation Safety Agency (EASA), and therefore does not fall into the scope of this Mandate. The avoidance of harmful interference which would endanger the functioning of aviation-related safety services takes priority over any other issue.

**JUSTIFICATION**

The first Mandate given by the Commission to CEPT on 12 October 2006 on this issue led to a final CEPT Report being delivered to the Commission on 30 March 2007 (doc. RSCOM07-08) and to a subsequent Commission Decision 2008/294/EC on harmonised conditions of spectrum use for the operation of mobile communication services on aircraft (MCA services) in the European Union, which was adopted by the Commission on 7 April 2008.

<sup>2</sup> Decision 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community, OJ L 108 of 24.4.2002, p.1.



Allowing people to be connected everywhere at all time is a recurring theme of the policy on the Information Society and of the i2010 initiative. The development of increased means of communicating is likely to be beneficial for work productivity and for growth in the mobile telephony market, for the fulfilment of the Digital Agenda for Europe, and must be in line with the principles of service and technology neutrality as defined in the regulatory framework for electronic communications. Airborne connectivity applications are being used mostly for cross-border flights within the European Union, as well as for flights departing from and arriving in the European Union, and are pan-European in nature. The inclusion of new appropriate technologies and frequencies for the use of MCA services would therefore further support the objectives of the EU Single Market.

#### **ORDER AND SCHEDULE**

CEPT is hereby mandated to undertake all required activities to

- (1) assess specific technical compatibility issues between the operation of airborne UMTS systems and other feasible airborne technologies, such as LTE or WiMax, in relevant frequency bands, including the terrestrial 2 GHz band (1920-1980 MHz and 2110-2170 MHz), and potentially affected radio services, taking into account the technical conditions developed in CEPT Report 39 for the assessment relating to the terrestrial 2 GHz band;
- (2) assess the technical compatibility issues between the operation of airborne UMTS systems and other feasible airborne technologies such as LTE or WiMax in other frequency bands (e.g. the 2.6 GHz band) and identify potentially affected radio services.

CEPT shall undertake this work in full awareness of and close collaboration with developments regarding the airworthiness certification of these systems by aviation safety authorities.

CEPT should provide deliverables according to the following schedule:

<b>Delivery date</b>	<b>Deliverable</b>	<b>Subject</b>
20 June 2012	Interim Report from CEPT to the Commission	Description of work undertaken and interim results under this Mandate.
21 November 2012*	Final Report from CEPT to the Commission	Description of work undertaken and final results under this Mandate
6 March 2013	Final Report from CEPT to the Commission, taking into account the outcome of the public consultation	

\* subject to subsequent public consultation

In addition, CEPT is requested to report on the progress of its work pursuant to this Mandate to all the meetings of the Radio Spectrum Committee taking place during the course of the Mandate.

The result of this Mandate can be made applicable in the European Union pursuant to Article 4 of the Radio Spectrum Decision.

In implementing this Mandate, the CEPT shall take the utmost account of EU law applicable.

\*\*\*\*

## ANNEX 2: LIST OF REFERENCE

- [1] ECC Report 187 on compatibility study between mobile communication services on board aircraft (MCA) and ground-based systems.
- [2] ECC Decision (06)07 on the harmonised use of airborne GSM systems in the frequency bands 1710-1785 and 1805-1880 MHz.
- [3] ECC Report 093 "compatibility between GSM equipment on board aircraft and terrestrial networks"
- [4] ECC Report 174 "Compatibility between the mobile service in the band 2500-2690 MHz and the radiodetermination service in the band 2700-2900 MHz".
- [5] Recommendation ITU-R RA.769-2 "Protection criteria used for radio astronomical measurements "
- [6] Recommendation ITU-R M.1464-1, June 2003, "Characteristics of radiolocation radars, and characteristics and protection criteria for sharing studies for aeronautical radionavigation and meteorological radars in the radiodetermination service operating in the frequency band 2 700-2 900 MHz".
- [7] Commission Decision 2008/294/EC, Commission Decision of 7 April 2008 on harmonised conditions of spectrum use for the operation of mobile communication services on aircraft (MCA services) in the Community.
- [8] CEPT Report 39: Report from CEPT to the European Commission in response to the Mandate to develop least restrictive technical conditions for 2 GHz bands.
- [9] CEPT Report 016: Report from CEPT to the European Commission in response to the Mandate on Mobile Communication Services on board aircraft (MCA).



13-301  
**CEPT REPORT 16**  
12 June 2007

**ACCEPTED/FILED**

JAN 23 2014

Federal Communications Commission  
Office of the Secretary



CEPT Report 16

Report from CEPT to the European Commission  
in response to the EC Mandate on

Mobile Communication Services on board aircraft (MCA)

Final Report on 30 March 2007 by the:



Electronic Communications Committee (ECC)  
within the European Conference of Postal and Telecommunications Administrations (CEPT)



## 0 EXECUTIVE SUMMARY

This final report considers the impact of Mobile Communication Services onboard Aircraft (MCA) to ground-based mobile networks. The study assumes the operation of the MCA system at a height of at least 3000 m above ground level in the 1800 MHz frequency band (1710-1785 MHz for uplink (terminal transmit, base station receive) / 1805-1880 MHz for downlink (base station transmit, terminal receive)).

The MCA system considered in the report consists of a Network Control Unit (NCU) to ensure that signals transmitted by ground-based mobile systems are not visible within the cabin and an aircraft BTS (ac-BTS) which provides the connectivity. Combined they are designed to ensure that the mobile stations on board the aircraft (ac-MS) only transmit at the minimum level of 0 dBm nominal value with a 0 dBi antenna gain and are not able to connect directly to ground based mobile networks. The parameters for the NCU and ac-BTS were derived from theoretical models.

The following ground based mobile networks have been addressed: GSM900, GSM1800, UMTS900, UMTS1800, UMTS in the 2 GHz FDD core band and CDMA-450/FLASH-OFDM (CDMA2000/ FLASH-OFDM at around 450 MHz).

CEPT recognizes that the avoidance of harmful interference which might endanger the functioning of aviation-related safety services takes priority over any other issue. **However, this report will not address the regulatory and operational aspects or EMC issues related to the aircraft avionics, since these issues are outside CEPT responsibilities.**

For the estimation of the impact on the ground based mobile systems, two methodologies have been used: the worst case methodology MCL (Minimum Coupling Loss) and simulations with SEAMCAT<sup>1</sup> taking into account random distributions of the aircraft around a receiver on the ground. The free space path propagation model was used between the aircraft and ground based mobile networks for all interference scenarios. Inside the cabin, a leaky feeder antenna was assumed.

The studies were based on typical values of network equipment parameters (as provided by manufacturers and operators) where available. Otherwise, reference values extracted from the standards were used.

The studies have demonstrated that the maximum values of the radiations from the MCA system, in order to protect ground networks, depend on the elevation angle at which the ground victim receiver sees the interfering aircraft. Since this elevation angle changes as the aircraft flies, the worst-case elevation angles were assumed when deriving radiation limits, i.e. the victim terminal is directly below the aircraft or the victim base station is close to the horizon as seen from the aircraft.

The studies have shown that there is no significant increase of the level of interference due to MCA emissions from multiple aircraft since the dominant source of interference to a terminal on the ground is the MCA in the closest aircraft.

The attenuation due to the aircraft is a crucial factor when undertaking compatibility studies involving MCA systems, in particular when considering how the emission limits outside the aircraft should relate to the actual parameters of the MCA system equipment (notably output power for NCU/ac-BTS and their antenna type and radiation characteristics). However this factor is highly dependent on the individual aircraft features such as:

- the aircraft type/variant;
- the characteristics of the aircraft RF isolation;
- the propagation characteristics within the cabin;
- the installation of the MCA system.

To avoid harmful interference to ground-based networks (using the criterion  $I/N < -6$  dB), the e.i.r.p. densities given in Table 1 should not be exceeded. These limits are defined as levels outside the aircraft in order to meet this objective, despite the variation in aircraft attenuation due to the factors described above.

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<sup>1</sup> Spectrum Engineering Advanced Monte Carlo Analysis Tool developed for compatibility studies within CEPT, available from [www.ero.dk/seamcat](http://www.ero.dk/seamcat).

Minimum operational height above ground (m)	Maximum permitted e.i.r.p. density produced by ac-MS, defined outside the aircraft (dBm/200 kHz)	Maximum permitted e.i.r.p. density produced by NCU/aircraft-BTS, defined outside the aircraft				
		Ac-BTS	NCU			
		1800 MHz	450 MHz	900 MHz*	1800 MHz*	2GHz
		(dBm/200 kHz)	(dBm/1250 kHz)	(dBm/200 kHz)	(dBm/200 kHz)	(dBm/3840 kHz)
3000	-3.3	-13.0	-17.0	-19.0	-13.0	1.0
4000	-1.1	-10.5	-14.5	-16.5	-10.5	3.5
5000	0.5	-8.5	-12.6	-14.5	-8.5	5.4
6000	1.8	-6.9	-11.0	-12.9	-6.9	7.0
7000	2.9	-5.6	-9.6	-11.6	-5.6	8.3
8000	3.8	-4.4	-8.5	-10.5	-4.4	9.5

**Table 1: Maximum permitted e.i.r.p. density of MCA emitting entities, defined outside the aircraft**

\*The reference bandwidths quoted in these columns refer to the GSM carrier spacing. However, these e.i.r.p. densities are equally applicable for the protection of UMTS (WCDMA) networks.

To summarize, this report defines the conditions under which MCA can be operated, with a minimum height of at least 3000 m above ground level, without causing harmful interference to ground-based mobile networks (either in the GSM1800 band or in any other bands in which the onboard mobile terminals would be capable of transmitting). Note that in order to meet these conditions care will need to be taken over the installation and operation of the MCA system.

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## 1 INTRODUCTION

This is the report by the European Conference of Postal and Telecommunications Administrations (CEPT) to the European Commission (EC) in response to the Mandate on Mobile Communication services onboard Aircraft (MCA). Pursuant to Article 4 of the Radio Spectrum Decision, CEPT is mandated to undertake the work required to identify the most appropriate technical criteria for the timely and harmonized introduction of MCA applications in the European Union.

The Mandate was issued to CEPT in October 2006 (RSCom #17) and addresses the airborne GSM1800-based mobile communication systems.

This report has been developed within CEPT/ECC/WGSE Project Team 7 (SE7) with contributions from Administrations and industry. The associated report (ECC Report 093) was approved by the CEPT/ECC/WGSE meeting in September 2006.

## 2 ABBREVIATIONS

<b>MCA</b>	Mobile Communication services onboard aircraft
<b>Ac-</b>	aircraft- (prefix)
<b>Ac-BTS</b>	GSM base station located onboard
<b>Ac-MS</b>	GSM mobile station located onboard
<b>Ac-UE</b>	UMTS User Equipment located onboard
<b>AGS</b>	Aircraft GSM Server
<b>Antenna pattern</b>	refers to the modelling of formulas (e.g.: an ITU-R recommendation)
<b>BS</b>	Base Station
<b>BTS</b>	Base Transceiver Station
<b>BW</b>	Bandwidth
<b>CDMA</b>	Code Division Multiple Access
<b>CIDS</b>	Cabin Intercommunication Data System
<b>e.i.r.p.</b>	Equivalent Isotropically Radiated Power
<b>FDD</b>	Frequency Division Duplex
<b>FLASH-OFDM</b>	Fast Low latency Access with Seamless Handoff using Orthogonal Frequency Division Multiplexing.
<b>g-</b>	ground (prefix)
<b>g-BS</b>	CDMA2000 base station located on the ground
<b>g-BTS</b>	GSM Base Station located on the ground
<b>g-MS</b>	GSM Mobile Station located on the ground
<b>g-Node B</b>	UMTS base station located on the ground
<b>g-UE</b>	UMTS User Equipment located on the ground
<b>GPRS</b>	General Packet Radio Service
<b>GSM</b>	Global System for Mobile communications
<b>Leaky feeder</b>	A coaxial cable that is intended to act as an antenna by radiating RF power along its length. Also referred to as a radiating cable
<b>MCL</b>	Minimum Coupling Loss
<b>MS</b>	Mobile Station
<b>NA</b>	Not Applicable
<b>NCU</b>	Network Control Unit located onboard
<b>SEAMCAT</b>	Spectrum Engineering Advanced Monte-Carlo Analysis Tool (free software tool available from <a href="http://www.ero.dk/seamcat">www.ero.dk/seamcat</a> )
<b>SGSN</b>	Serving GPRS Support Node
<b>SMS</b>	Short Message Service
<b>Terminal</b>	General term given to a handheld device capable of connecting to a public mobile network
<b>UE</b>	User Equipment

<b>Visibility</b>	Ability of a terminal to decode the system information from a base station
<b>VMSC</b>	Visited Mobile Switching Center
<b>UMTS</b>	Universal Mobile Telecommunications System
<b>UTRA</b>	UMTS Terrestrial Radio Access
<b>WCDMA</b>	Wide Band CDMA (UTRA FDD)

### 3 BACKGROUND

This report considers the impact of introducing GSM mobile communication services onboard aircraft (MCA). The purpose of this study was to investigate the compatibility between GSM equipment (and some required additional equipment) used onboard an aircraft and ground-based networks. The MCA system is assumed to operate in the GSM1800 frequency band. Nowadays, many mobile terminals are multi-band or multimode terminals. Also some studies have shown that interactions between mobile terminals located onboard aircraft and ground based mobile networks are possible. Therefore, this report addresses GSM900, GSM1800, UMTS900, UMTS1800, UMTS in the 2GHz FDD core band and FLASH-OFDM/CDMA450 (FLASH-OFDM/CDMA2000 at around 450 MHz) ground based mobile networks.

Figure 1 shows an example of such a MCA system: an onboard cell is linked to backbone networks via a satellite link.

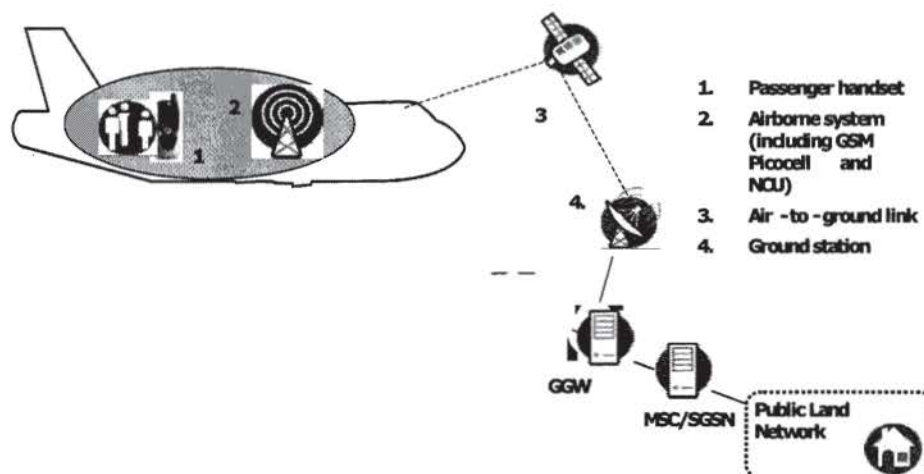


Figure 1: Overview of the MCA system and associated components

#### 3.1 Service description

MCA services would allow airline passengers to use their personal mobile terminals during approved stages of flight. Passengers can make and receive calls, send and receive SMS text messages and use GPRS functionality. The system provides a roaming GSM visited network access.

#### 3.2 Service environment

MCA services are to be deployed in aircraft intended for both national and international flights. Various ground based mobile networks are deployed in those countries. It is highlighted that:

- The frequency band used for onboard communications is the GSM1800 frequency band;
- The vast majority of user terminals are multi-band or multimode, so they are able to transmit in other frequency bands and / or technologies (GSM900, UMTS 2 GHz, etc.).

The system adopted for MCA therefore is designed to ensure that user terminals on an aircraft are unable to attempt to connect directly to ground-based mobile networks, whilst providing onboard connectivity. When there is no onboard service, passengers must switch off their mobile terminal in order to prevent direct connections to ground-based networks.



### 3.3 Mobile frequency bands and systems covered

#### Connectivity (ac-MS/ac-BTS):

The ac-BTS provides the communication access to the ac-MS and supports all necessary system features like radio access and radio resource management. The study assumes that the MCA system covers the following frequency bands for connectivity between the mobile terminals located onboard an aircraft (ac-MS/ac-UE) and the onboard aircraft Base Station Transceiver (ac-BTS):

- 1710-1785 MHz and 1805-1880 MHz (GSM1800)

#### Control (e.g. NCU):

To prevent interaction with ground-based mobile networks, the MCA system must cover the following frequency bands (e.g.: via Network Control Unit (NCU) operation):

- 460-470 MHz (CDMA450 / FLASH-OFDM downlink band)
- 921-960 MHz (GSM900 (including GSM-R) and WCDMA (UMTS 900) downlink band)
- 1805-1880 MHz (GSM1800 and WCDMA (UMTS1800) downlink band)
- 2110-2170 MHz (WCDMA (UMTS) 2 GHz FDD core band downlink).

The report is limited to the above mentioned frequency bands and systems and some further studies on fixed networks would be needed.

### 3.4 General architecture of a MCA system using a NCU

There are several technical and operational methods by which the electromagnetic isolation between the ac-MS/UE and the ground based mobile networks can be achieved via passive or active means, or a combination of the two. An example of an active solution is the use of a "Network Control Unit" (NCU). The complete MCA system including ground elements typically consists of an airborne and a ground segment, subdivided in two domains, see Figure 2.

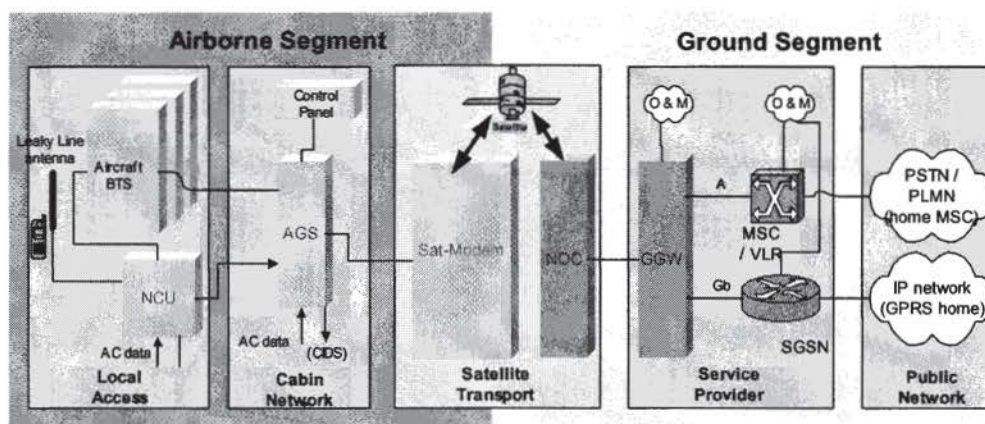


Figure 2: Overall end to end architecture of a complete MCA system

The airborne segment consists of the local access domain and the cabin network domain:

- The local access domain contains the ac-BTS and the NCU.
- The cabin network domain contains an Aircraft GSM Server (AGS) which is the interface between the main modules onboard, i.e. the ac-BTS, the NCU and the Sat-Modem.

The ground segment consists of a service provider domain and the public network domain:

- The service provider domain hosts communication controller functions that act together with the AGS functions in the aircraft. For this purpose, a Ground Gateway (GGW), and GSM visited network components (VMSC and SGSN) are required. Their main features are to perform the routing towards the aircraft, and to connect the aircraft traffic with backbone networks of the Public Network Domain;
- The public network domain provides the interconnection of the call, data or signalling communication to the relevant public network end points.

The satellite transport link connects the airborne and the ground segments.

The system description only covers the elements related to the MCA service and does not include aircraft systems, such as the avionics, as these are out of scope of this report. Note that the ground segment and the satellite transport link descriptions are for information only.

#### **4 DESCRIPTION OF THE COMPATIBILITY STUDY UNDERTAKEN**

The following provides a brief description of the work undertaken to complete ECC Report 093.

##### **4.1 Methodology used for compatibility study**

For the estimation of the impact on the terrestrial systems, two different methodologies were used: the worst case methodology MCL (Minimum Coupling Loss) and simulations using SEAMCAT<sup>2</sup> taking into account random distributions of the aircraft around a terrestrial station.

Free space path propagation was assumed between the aircraft and ground based mobile networks for all interference scenarios. Inside the cabin, a leaky feeder antenna was assumed.

##### **4.2 Scenarios studied**

The studies that have been carried out on the compatibility between MCA systems and ground based radiocommunication services are based on a number of assumptions relating to the characteristics of the "victim" services on the ground.

Using both models (SEAMCAT and MCL) the following six scenarios were studied:

- Scenario 1: Simulation of received signal level from ground networks into the aircraft
- Scenario 2: Simulation of received signal level at ground level of onboard mobile terminals transmitting at maximum power.
- Scenarios 3 and 4: Impact of MCA system emission (NCU and ac-BTS) to mobile terminals on the ground, for single (Scenario 3) and multiple (Scenario 4) aircraft respectively;
- Scenarios 5 and 6: Impact of ac-MS emissions to ground based mobile networks, for single (Scenario 5) and multiple (Scenario 6) aircraft respectively.

##### **4.3 Technical parameters of MCA system**

The aircraft cabin environment covers a number of parameters in order to simulate the e.i.r.p. of the aircraft seen from the ground. The two transmitting MCA entities in the aircraft are: the ac-BTS and the NCU.

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<sup>2</sup> Spectrum Engineering Advanced Monte Carlo Analysis Tool developed for compatibility studies within CEPT, available from [www.ero.dk/seamcat](http://www.ero.dk/seamcat).



#### 4.3.1 Ac-BTS

The MCA connectivity component is the ac-BTS. Given that the NCU transmits contiguously across the whole band, the ac-BTS will have to transmit at a higher power level per channel.

The ac-BTS is assumed to have the following characteristics:

- Support of standard GSM and GPRS services;
- Operating in the 1800 MHz frequency band;
- Operating at a sufficient power level (at least 12 dB over the NCU power level per channel i.e.: Pico-cell (ac-BTS): e.i.r.p. for GSM 1800 MHz connectivity = The NCU 1800 MHz e.i.r.p. value (dBm) + 12 (dB)).

#### 4.3.2 NCU

The NCU is assumed to have the following characteristics:

- No transmissions below 3000 m above ground;
- The signal generated is band-limited noise;
- The NCU transmits at dedicated minimum power to screen ground based mobile networks inside the aircraft and only transmitted above a certain height (power value dependent on frequency band and height);
- The power level may be reduced with increased height because of the decreased signal strength received in the aircraft from ground based mobile networks;
- The NCU covers the entire GSM, UMTS and CDMA2000 BTS/Node B/BS to Mobile (downlink) bands.

#### 4.3.3 Considerations relating to operation of MCA system

The MCA system is designed to ensure that ac-MS/UE are unable to attempt to communicate with ground based mobile networks, whilst providing onboard connectivity to ac-MS in the GSM1800 frequency band.

The ac-MS transmitted power is controlled by the ac-BTS to the minimum nominal power of 0 dBm/200 kHz in the 1800 MHz frequency band.

#### 4.4 Technical Parameters of ground based mobile systems studied

The parameters highlighted in this section reflect those used in the report. These values were based on typical values of network equipment parameters (as provided by manufacturers and operators) where available. Otherwise, reference values extracted from the standards were used.

System	Type	Bandwidth (BW) in kHz	TX Power (dBm/BW)	Maximum antenna gain (dBi)	Noise level (dBm/BW)
GSM900	MS	200	33	0	-114
	BS		43	15	-117
GSM1800	MS	200	30	0	-114
	BS		43	18	-117
UMTS 2 GHz	UE	3840	21/24*	0	-101
	Node B		43	18	-104
UMTS 900	UE	3840	21/24*	0	-99
	Node B		43	15	-103
UMTS 1800	UE	3840	21/24*	0	-99
	Node B		43	18	-103
FLASH OFDM/CDMA450	MS	1250	23	0	-101
	BS		43	18	-104

Table 2: Ground based system parameters used in ECC Report 093



\* Maximum UE transmit powers values quoted to be used for the following simulations:

- Maximum UE transmission power for an onboard UE = 24 dBm;
- Maximum terrestrial UE transmission power value for simulations on the impacts for the support of voice service = 21 dBm (assumes UE power class 4);
- Maximum terrestrial UE transmission power value for simulations on impacts for the support of non voice service = 24 dBm.

Antenna gain and patterns are estimated to be similar to existing GSM/UMTS networks and terminals currently deployed.

#### 4.5 Additional considerations used in the compatibility study

In order to carry out the compatibility study a number of additional considerations were made:

- A bespoke cylinder model was used to calculate the necessary power needed for the NCU to control the cabin environment based on the expected strongest ground signal received at the aircraft window for the various frequencies and technologies studied.
- Additional power margins were added to the model to account for in cabin RF fluctuations based on a large aircraft configuration (these margins increased the required power of the MCA system).
- The same cylinder model was used to determine the effective power radiated by the aircraft to the ground.
- Real data busy hour distributions of aircraft over a built up air space were used to calculate the impacts of multiple aircraft.
- An interference criterion of  $I/N < -6$  dB to systems on the ground was used (equivalent to a 1 dB increase of the noise floor of the receiver).

### 5 RESULTS OF COMPATIBILITY OF MCA SYSTEMS ON TO NETWORKS ON THE GROUND

The results of the compatibility study showed that it is possible for onboard mobile terminals to identify networks on the ground and may be able to successfully communicate with those networks. Consequently if mobile terminals are allowed to be used in an aircraft then the environment must be created so that those onboard mobile terminals are not able to detect networks on the ground when the MCA system is operational

Assuming that an active control device is used then the report studied the impact of the:

- *NCU emissions into the Ground based Downlink* (base station transmit → mobile station receive link);
- *ac-BTS emissions into the Ground based Downlink* (base station transmit → mobile station receive link), at 1800 MHz only;
- *ac-MS emissions into the Ground based uplink* (mobile station transmit → base station receive link).

The results of these analyses of the MCA system have shown that the worse case simulations occur for a single aircraft using MCL analysis based on the requirements for a large aircraft simulation (wide body). Simulations on impacts due to multiple aircraft have shown that the effect is less than expected due mainly to the fact that the dominant source of interference to a terminal on the ground is that from the closest aircraft, but also because not all aircraft flying are wide body.

Results of the studies have also shown that a system can be built that both satisfies the condition to control the aircraft cabin environment (minimum power level) and provide cabin connectivity with sufficient margin (12 dB margin over NCU power) whilst not causing more than 1 dB elevation in the noise floor of the receivers of ground based mobile networks for the various frequency bands and cellular technologies studied.

Consequently the studies on the compatibility of a MCA on to ground based mobile networks, when the aircraft is at least 3000 m above ground demonstrated that harmful interference to ground based mobile networks does not occur provided that the following technical conditions are met:

- The transmit power of ac-MS must be controlled by the MCA system to the minimum value (0 dBm nominal);
- ac-MS/UE not connected to the MCA network must be prevented from attempting to connect to ground based mobile networks (in both the GSM 1800 band and other relevant frequency bands), as this would disrupt the operation of these networks and cause interference to them;
- The aircraft fuselage will attenuate the total power entering or leaking from the cabin, but it might under some circumstances also act as a directive gain. If the cabin fuselage does not provide sufficient

attenuation, an active device such as an NCU can be used to mask the signals from ground based mobile networks that enter the cabin. The power of the masking signal from the NCU must be sufficient to reliably perform this function, but must not be high enough to cause harmful interference to ground based mobile networks in any of the frequency bands in which the NCU operates.

It was found that, if these conditions are not met, the received signal strength onboard the aircraft can be high enough for an ac-MS/UE to attempt to connect directly to a ground based mobile network even when an aircraft is at a high cruising altitude (10000 m above ground).

The levels of interfering signal to ground based mobile network and received from the ground by ac-MS/UE are strongly dependent on the height of the aircraft above ground, the average attenuation due to the aircraft and the directivity of the aircraft acting as an antenna. The studies indicate that there is a fine balance between the NCU transmitting at a sufficient power level to remove visibility of the ground based mobile networks and provide g-BTS connectivity for GSM coverage, whilst not being so high that the NCU signal itself causes harmful interference to ground based mobile networks.

The attenuation due to the aircraft is a crucial factor when undertaking compatibility studies involving MCA systems, in particular when considering how the emission limits outside the aircraft should relate to the actual parameters of the MCA system equipment (notably output power for NCU/ac-BTS and their antenna type and radiation characteristics). However this factor is highly dependent on the individual aircraft features such as:

- the aircraft type/variant;
- the characteristics of the aircraft RF isolation;
- the propagation characteristics within the cabin;
- the installation of the MCA system.

To avoid harmful interference to ground-based networks (using the criterion  $I/N < -6$  dB), the e.i.r.p. densities given in Table 3 should not be exceeded. These limits are defined as levels outside the aircraft in order to meet this objective, despite the variation in aircraft attenuation due to the factors described above.

Minimum operational height above ground (m)	Maximum permitted e.i.r.p. density produced by ac-MS, defined outside the aircraft (dBm/200 kHz)	Maximum permitted e.i.r.p. density produced by NCU/aircraft-BTS, defined outside the aircraft				
		Ac-BTS	NCU			
		1800 MHz	450 MHz	900 MHz*	1800 MHz*	2GHz
		(dBm/200 kHz)	(dBm/1250 kHz)	(dBm/200 kHz)	(dBm/200 kHz)	(dBm/3840 kHz)
3000	-3.3	-13.0	-17.0	-19.0	-13.0	1.0
4000	-1.1	-10.5	-14.5	-16.5	-10.5	3.5
5000	0.5	-8.5	-12.6	-14.5	-8.5	5.4
6000	1.8	-6.9	-11.0	-12.9	-6.9	7.0
7000	2.9	-5.6	-9.6	-11.6	-5.6	8.3
8000	3.8	-4.4	-8.5	-10.5	-4.4	9.5

Table 3: Maximum permitted e.i.r.p. density of MCA emitting entities, defined outside the aircraft

\*The reference bandwidths quoted in these columns refer to the GSM carrier spacing. However, these e.i.r.p. densities are equally applicable for the protection of UMTS (WCDMA) networks.

The studies have shown that there is no significant increase in interference due to MCA emissions from multiple aircraft since the dominant source of interference to a terminal on the ground is MCA in the closest aircraft.

## 6 TECHNICAL CONDITION TO ALLOW THE USE OF MCA SYSTEM

The MCA system enables airline passengers to use their personal mobile terminals during approved stages of flight. GSM access onboard aircraft is provided by one or more pico cell BTS (aircraft-BTS). Onboard mobile terminals must be prevented from attempting to access networks on the ground. This could be ensured:



- By the inclusion of a Network Control Unit (NCU), which raises the noise floor inside the cabin in mobile receive bands and/or;
- Through RF shielding of the aircraft fuselage to further attenuate the signal entering and leaving the fuselage.

The power of the onboard mobile terminals is controlled to the minimum value by the GSM 1800 aircraft-BTS. This band has been selected because the minimum transmit power of the mobile terminal is lower than for the GSM 900 band and the path loss is higher for the 1800 MHz frequency band. The NCU output power must be sufficient to remove "visibility" of the networks located on the ground, whilst not being so high as to cause harmful interference to these networks. Similarly the power of the aircraft-BTS should be sufficient to provide a reliable service, without causing harmful interference to networks on the ground.

#### 6.1 Prevention of mobile terminals from attaching to networks on the ground

During the period when the use of mobile terminals is authorized on an aircraft, terminals operating within the frequency bands defined in Table 4 shall be prevented from attempting to register with networks on the ground.

Frequency band (MHz)	Considered systems on the ground <sup>3</sup>
460–470	CDMA2000, FLASH OFDM
921–960	GSM, WCDMA
1805–1880	GSM, WCDMA
2110–2170	WCDMA

**Table 4 : Victim ground networks considered in the study**

If an NCU is used, the noise power radiated by the NCU must be sufficient to prevent terminals from receiving and connecting to networks on the ground, while also meeting the requirement described in section 5.3, for maximum power radiated from the aircraft in mobile receive bands<sup>4</sup>.

#### 6.2 Minimum height for operation

The absolute minimum height above ground for any transmission from the MCA system in operation shall be 3,000 metres. However, this minimum height requirement could be set higher, in particular:

- in order to comply with the aircraft-BTS and the onboard terminals emission requirements,
- depending on the terrain and related network deployments in a country.

<sup>3</sup> The parameters of the considered victim systems were used when defining the limits described in this report; see ECC report 093 for the values assumed in the studies.

<sup>4</sup> If these two requirements cannot be simultaneously met for a particular aircraft height, the minimum height for the operation of the MCA system must be increased.



### 6.3 e.i.r.p. from the NCU/aircraft-BTS, outside the aircraft

The total e.i.r.p. density, defined outside the aircraft, resulting from the NCU/aircraft-BTS shall not exceed<sup>5</sup>:

Height above ground (m)	Maximum e.i.r.p. density produced by NCU/aircraft-BTS, outside the aircraft			
	460-470 MHz	921-960 MHz	1805-1880 MHz	2110-2170 MHz
	dBm/1.25 MHz	dBm/200 kHz	dBm/200 kHz	dBm/3.84 MHz
3000	-17.0	-19.0	-13.0	1.0
4000	-14.5	-16.5	-10.5	3.5
5000	-12.6	-14.5	-8.5	5.4
6000	-11.0	-12.9	-6.9	7.0
7000	-9.6	-11.6	-5.6	8.3
8000	-8.5	-10.5	-4.4	9.5

Table 5: e.i.r.p. density produced by NCU/aircraft-BTS, outside the aircraft

It should be noted that the limits, defined in the Table 5, are dependent on the elevation angle at the victim terminal on the ground. The values contained in the table are for the case where the victim terminal is directly below the aircraft, and are therefore conservative.

### 6.4 e.i.r.p. from the onboard terminal outside the aircraft

The e.i.r.p. density, defined outside the aircraft, resulting from the GSM mobile terminal transmitting at 0 dBm shall not exceed<sup>5</sup>:

Height above ground (m)	Maximum e.i.r.p. density, defined outside the aircraft, resulting from the GSM mobile terminal (operating in the 1800 MHz band) in dBm/200 kHz
3000	-3.3
4000	-1.1
5000	0.5
6000	1.8
7000	2.9
8000	3.8

Table 6 : e.i.r.p. density, defined outside the aircraft, resulting from the GSM mobile terminal

It should be noted that the limits, defined in Table 6, are dependent on the elevation angle at the victim base station on the ground. The values contained in the table correspond to an angle of elevation of 2°, which are conservative.

### 6.5 Operational requirements

The aircraft-BTS shall control the transmit power of all mobile terminals, transmitting in the GSM 1800 band, to the minimum nominal value of 0 dBm at all stages of communication, including the initial access.

It is necessary that appropriate measures are taken to ensure that onboard terminals are switched off when the MCA system is not in operation and that mobile terminals not controlled by the MCA system (such as those from professional mobile networks) remain switched off during all the phases of the flight.

<sup>5</sup> The values quoted in the Tables 5 and 6 correspond to a maximum increase of the receiver noise floor of 1 dB (i.e.  $I/N \leq -6$  dB) with a high statistical confidence using the most sensitive types of base stations and terminals.

## **7 CONCLUSION**

This report has described the conditions under which MCA systems can be operated when more than 3000 m above ground level assuming an interference criterion of up to 1 dB increase of the noise floor of ground based mobile receivers. Conformance to these conditions prevents harmful interference to ground based mobile networks (either in GSM1800 band or in any other frequency bands in which the onboard mobile terminals would be capable of transmitting).

Note that in order to meet these conditions care will need to be taken over the installation and operation of the MCA system.

## ANNEX 1

## MANDATE TO CEPT ON MOBILE COMMUNICATIONS SERVICE ONBOARD AIRCRAFT

## DRAFT

## MANDATE TO CEPT ON MOBILE COMMUNICATION SERVICES ON BOARD AIRCRAFT (MCA)

**Title**

Mandate to CEPT to identify the technical conditions required to ensure the compatibility of operation with existing radiocommunication services of GSM systems on board aircraft in the frequency bands 1710–1785 and 1805–1880 MHz in the European Union.

**Purpose**

Pursuant to art. 4 of the Radio Spectrum Decision, CEPT is mandated to undertake the work required to identify the most appropriate technical criteria for the timely and harmonised introduction of MCA applications in the European Union.

This present mandate limits itself to the study of technical compatibility of airborne GSM1800 systems with potentially affected radio services. The limitation is justified by the expectation that MCA services will be implemented using this technology at first, and therefore needs to be prioritised. Further EC mandates targeting other technologies may be prepared in the future.

In the European Union, the airworthiness of airborne GSM1800-based mobile communication systems to avoid harmful interference to aviation systems is the competence of the European Aviation Safety Agency (EASA), as is therefore not the competence of this Mandate. The avoidance of harmful interference which would endanger the functioning of aviation-related safety services takes priority over any other issue.

**Justification**

Allowing people to be connected everywhere at all time is a recurring theme of the policy on the Information Society and of the i2010 initiative. The development of additional means of communicating is likely to be beneficial for work productivity and for growth in the mobile telephony market. Airborne connectivity applications would be used mostly for cross-border flights within the European Union and are pan-European in nature. A coordinated approach to the regulation of such services would support the objectives of the EU Single Market for persons by facilitating cross-border travel.

**Order and Schedule**

CEPT is hereby mandated to undertake all required activities to assess specific technical compatibility issues between the operation of airborne GSM 1800 systems and a number of potentially affected radio services.

CEPT shall undertake this work in full awareness of and close collaboration with developments regarding the airworthiness certification of these systems by aviation safety authorities.



CEPT is mandated to provide deliverables according to the following schedule:

<b>Delivery date</b>	<b>Deliverable</b>	<b>Subject</b>
1 <sup>st</sup> December 2006	Interim Report from CEPT to the Commission	Description of work undertaken and interim results under this Mandate.
1 <sup>st</sup> April 2007	Final Report from CEPT to the Commission	Description of work undertaken and final results under this Mandate

In addition, CEPT is requested to report on the progress of its work pursuant to this Mandate to all the meetings of the Radio Spectrum Committee taking place during the course of the Mandate.

The result of this Mandate can be made applicable in the European Community pursuant to Article 4 of the Radio Spectrum Decision<sup>2</sup>.

In implementing this Mandate, the CEPT shall take the utmost account of Community law applicable.

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<sup>2</sup> Decision 676/2002/EC of the European Parliament and of the Council of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community, OJ L 108 of 24.4.2002, p.1.